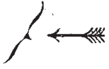
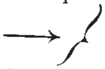
I should say, perhaps, that the birds maintain the kite-like incline, *all round the windward portion* of the spiral, thus  and appear to gain elevation in sweeping round while thus at an angle; at first facing the breeze, and as they sweep round being side on, as per diagram, the centrifugal element coming into play. If very low down, indeed, the bird can be seen to rise distinctly as it wheels round the windward edge of the curve, and reaches its greatest elevation just as it turns tail to wind. Then it seems to shoot along down a slight incline with wings horizontal, and in rounding the leeward part of the spiral, the outer wing is again spiral, thus . The speed of the bird so greatly exceeding that of the wind, renders this necessary to enable it to turn.

Viewed from below, the tracks look circular, and often vary in size a good deal.

In all cases, so far as I have seen, these birds when rising, as they sail round and round, make leeway, say a mile for every 1000 feet rise, or less.

They never rise on a straight course, though they often descend in a straight line, and, after a time, flocks that drift over the hills recover their position over the plains by descending to windward.

But in all these cases of land-birds rising steadily as they sail round and round, there is no possibility of lifting by waves, as at sea, nor yet differences in the *speed of air strata* every 20 feet or so, as they sail at all heights, from 500 feet up to 10,000 or more.

The problem is much more clearly seen, and more wonderful, than in the case of the albatross, and, as far as I can see, the explanation which I gave years ago is the only one feasible. The momentum gained in descending a given distance *with the wind* is expended in lifting the bird kite-like as it turns and *faces* the wind, on the shorter windward course, where also a certain amount of centrifugal reaction comes into play and does some of the *work*.

S. E. PEAL.

Sibsagar, Assam, August 8.

Bishop's Ring and Allied Phenomena.

Is there any connection between the sunset glows seen by Mr. S. E. Bishop in the Sandwich Islands (see p. 415) and the phenomena which have occurred lately in Western Europe? There has been for two months a feeble reappearance of a great corona round the sun. I do not know whether I can call it Bishop's ring, as it has generally been larger than that caused by the Krakatão dust, and also more dirty-looking in colour, and doubtless at a lower level. Bishop's ring itself had never altogether ceased to be visible about sunset and sunrise, but I had not certainly seen it at any time when the sun has had a considerable altitude for nearly two years, and then only in the clear Alpine air. On May 14 and August 26, 1888, there was indeed a great corona, but on the latter occasion the air was not very clear, so I concluded it probably had some other cause than volcanic dust; and there have been a few other occasions before that when I have had the same impression. On May 14, 1888, it is also questionable whether the circle was caused by volcanic dust.

The present corona appeared all at once on June 30 last, while I was at Macugnaga, at the foot of Monte Rosa; and since that date, both travelling in the Alps and here (since I came home on August 8) it has continued more or less visible at all times of the day when not obscured by mist or smoke, except from the afternoon of July 1 until the afternoon of the 2nd. It is plainest about sunset. It first appeared on cloudy streaks like very thin indefinite cirrus, but these disappeared during July 1. Since it appeared the sky has never been such a pure blue as it was before; this applies to all altitudes from sea-level to 10,000 feet.

I have not seen any remarkable sunset phenomena, so that it seems difficult to connect this circle with the phenomena noticed by Mr. Bishop a fortnight later than this commenced; still the connection is not impossible, as he mentions seeing the central (and by far the brightest) part of the corona.

Although it is improbable that the dust of Krakatão can have entirely settled to the ground, the above description will show that the present phenomenon can hardly be caused by it; but there must be a very extensive diffusion of some kind of dust—it may be one of the kinds alluded to by Prof. Tyndall and others in the discussion which occurred in your pages last year.

Sunderland, September 21. T. W. BACKHOUSE.

OBSERVATIONS OF TWILIGHT AND ZODIACAL LIGHT DURING THE TOTAL ECLIPSE OF THE SUN, DECEMBER 21, 1889.

THE attention of all friends of astronomy and meteorology, and especially of navigators on the ocean, and of meteorological observers in India and Mexico, is respectfully called to the fact that they may make valuable observations during the coming total eclipse of the sun. The observations referred to are of a most elementary character, and pertain to the phenomena of twilight and of the zodiacal light. The importance of the observations to be described was first appreciated by German meteorologists, and the following paragraphs are based upon suggestions made by Prof. Bezold and Dr. Zenker, of Berlin.

On December 22, 1889, at 47 minutes before noon, Greenwich time (which corresponds with 6 hours and 13 minutes a.m. of standard Eastern time) our globe becomes tangent to the long cone that constitutes the shadow of total darkness behind the moon, and we say that "totality has begun on the earth"; this occurs at a point in the Caribbean Sea, north of Venezuela, at about 15° N. lat. and 72½° W. long. In about three hours and a quarter this zone of total eclipse has passed the earth; its last point of contact, or tangency, occurs at a point on the eastern coast of Africa at about 5½° N. lat. and 49° E long. The path of totality on the earth's surface between these two limits is a narrow belt, about 100 miles broad, and astronomers will station themselves at favourable localities in order to observe the phenomena visible immediately around the sun, but meteorologists and local amateurs residing entirely outside the path of totality can also do good work.

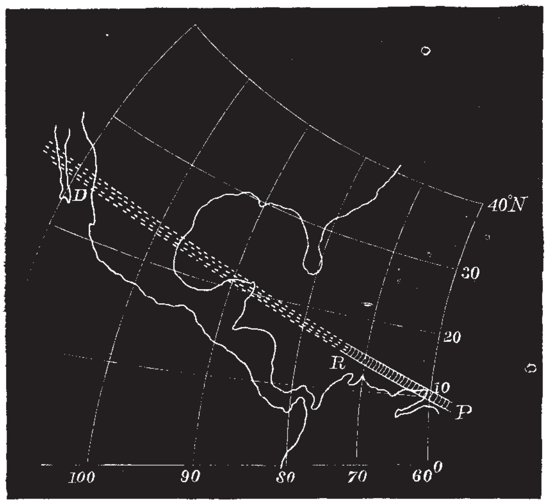
The accompanying diagrams, I., II., III., IV., will illustrate the conditions of the eclipse and the nature of the meteorological observations desired to be made. Thus in diagram I. we see the point R, or the locality where the totality begins to an observer on the earth; at that point the sun rises while it is totally eclipsed, and the band from R to P shows the path of the shadow as it flies eastward. Diagram II. takes up the path at its other end, and shows it still moving eastward from P towards S, where it finally leaves the earth, so that an observer at S sees the sun in his western horizon, but totally eclipsed as it is setting out of sight.

If we now imagine a vertical plane passing through the observer and the eclipsed sun, it will give us a section of the earth, its atmosphere, and the cone of darkness very much as shown in diagrams II. and IV. In diagram II. R represents, as before, the locality where the sun rises eclipsed, the moon is to the east of the observer, and the cone of darkness passes over him towards its apex, which is far off towards the west. Those who are located to the west of R, as at D, looking eastward, cannot see the sun because it is below their horizon; they can see only the light of the morning dawn where the sun is about to rise, but these observers, if they look directly toward the brightest part of the dawn, immediately over the sun, will, on this morning of December 22, find that they are looking right into the shadow of the cone, and will therefore observe that the light of the dawn is for a few minutes much feebler than usual.

Similarly diagram IV. shows the condition of things at the point S, where the observer at sunset has the cone of darkness imediately above him; observers to the east of his location, as at T, will be enjoying twilight, and as they look toward the west, immediately above the sun, they will be looking into the cone of darkness, and will find the twilight correspondingly diminished.

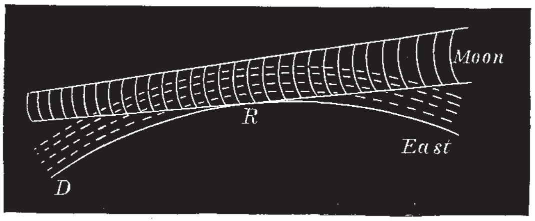
The distance from K to D in Fig. 1, and from S to T in diagram II., represents about 35° or 40° of the great circle, or over 2000 miles on the earth's surface; all persons located in this immense region—namely, all on vessels in the Caribbean Sea and Gulf of Mexico, the Arabian Sea—and all meteorological observers in Northern Mexico, Yucatan, Jamaica, and Western India, should be on the watch for phenomena of the following kind:—

(1) Note when the moon's shadow becomes first or last visible by the darkness of the high cirrus, haze, or the tops of cumulus clouds or the tops of mountains.



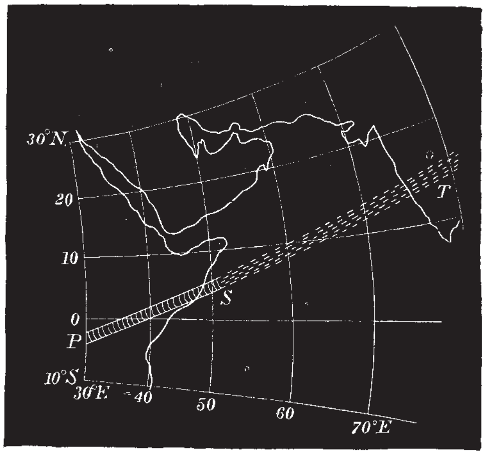
I.

(2) When the darkness is at its maximum, its boundary appears as a curved band of colours convex to the horizon, disturbing the otherwise horizontal arrangement of the illumination that constitutes the dawn or twilight. Note the angular distance of this boundary above the horizon at several points to the right and left of the sun. Note also the colours and their arrangement, both in the twilight proper and in the shaded portions. Note especially how far to the right or left the disturbance of the twilight or dawn appears to extend. By distance, of course, is meant apparent angular distance; but if the observer is so located that distant mountain-tops are visible, he should note whether they also show any phenomena due to the moon's shadow.

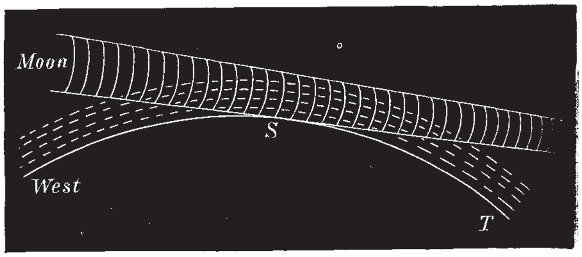


II.

(3) Owing to the fact that the observers at D and T are looking through a portion of atmosphere that does not receive its ordinary amount of light from the sun, they will be able to see objects that ordinarily would be hidden by the glare of twilight, such as fainter stars, and especially the Milky Way, and the zodiacal light. The latter object is one of special interest. It is desirable that observers should carefully record the appearance of zodiacal light for several days before and after the eclipse, as also on the 22nd itself, in order that we may distinguish between local atmospheric effects and those due to the eclipse. During the morning dawn in the region R D, and during the twilight S T, one should observe that the zodiacal light attains an unusual brilliancy and extent; the points to be noted are, first, how much further up from the horizon, or from the sun, is the beam of zodiacal light visible during the few minutes when the cone of shadow comes between it and the observer; again, how much nearer down toward the sun does it extend; and, again, how much broader is it toward the right and left? Does its colour appear changed? Sometimes several portions of the zodiacal light appear brighter than the neighbouring regions, therefore observe whether, as seen through the conical shadow, these differences disappear and the whole zodiacal light has a uniform gradation in intensity from the sun outward toward its extremity. Sometimes pulsations or waves of brightness and darkness have appeared to proceed from near the sun, reaching the extremity of the zodiacal light in the course of five or ten seconds; note whether any such phenomena are visible.



III.



IV.

The zodiacal light has been, on good authority, observed very high above the east and west horizon, so that some maintain that it is continuous through the zenith, and therefore surrounds the earth. This view may possibly be tested by observers located anywhere near the equator and a long way off from the path of totality. Therefore everyone should keep a record of the zodiacal light if he is so located as to see it at all during a few days before and after the eclipse and several hours before sunrise and after sunset. If observations show that the brightness of the zodiacal light is materially diminished during totality, in any part of the region where the moon's shadow darkens the atmosphere, this will go far to show that the zodiacal light originates in the earth's atmosphere; but if, as seen through the shaded air, the zodiacal light appears brighter than ever, it would follow that its location is far from us, and that it is an appendage of the sun.

(4) The observers of the zodiacal light should not fail to record the phenomena sometimes seen on the opposite side of the horizon, and called *Gegenschein*, or the anti-zodiacal light. Similarly, observers of the twilight phenomena should record the appearances in the horizon at the opposite side of the sun, or the so called anti-twilight arc, or band.

(5) Observers to whom the sun is beyond the horizon, and for whom the atmosphere between them and the sun is not illumined owing to the presence of the moon's shadow, will have a good opportunity, for a few minutes, to see any faint comet that may have been hidden to astronomers by the glare of the sunlight, and, if such should be seen, they should record the apparent altitude and azimuth of the nucleus.

The diagrams I. and III. trace the shadow-cone westward to South California and eastward to India, but this should not prevent observers still further west on the Pacific, or east over India and Japan, from recording and reporting such phenomena as they may observe.

Washington, August. CLEVELAND ABBE.

THE BRITISH ASSOCIATION.

SECTION D.

BIOLOGY.

OPENING ADDRESS BY PROF. J. S. BURDON SANDERSON, M.A., M.D., LL.D., F.R.SS. L. & E., PRESIDENT OF THE SECTION.

IT has long ceased to be possible in the course of an annual address in Section D to give an account even of the most important advances which have been made during the preceding twelve months in the various branches of knowledge which are now included under the term Biology. One reason is that each of the biological subjects has acquired such vast dimensions; the other, that the two main branches—Morphology, which strives to explain why plants and animals have assumed the forms and structure which they possess, and Physiology, which seeks to understand how the living organism works—have now diverged from each other so widely as regards subject and method, that there seems to be danger of complete separation of the one from the other.

From this sundering of sciences which a generation ago were intimately united, however inevitable it may be, Physiology chiefly suffers, as being even to the naturalist less attractive and interesting. The study of form and structure has the great advantage that it brings the observer into direct relation with objects which excite his curiosity without requiring too great an effort to understand them. This was the case even when Anatomy was mainly descriptive, and Zoology and Botany occupied themselves chiefly with classification and with definition of species. How much more is it the case now that Anatomy, Zoology, and Botany have become built into one system, of which the Doctrine of Evolution is the corner stone! Morphology, the name now given to this system, has, if I am not mistaken, this advantage over all other subjects of scientific study—that while attractive to the beginner, it is perfectly satisfactory to the mature student. It derives its perfectness from its subject—the *order* of the plant and animal world. For inasmuch as its fundamental conception is the development of all organisms, however complicated, from elementary forms, and as the theoretical development of the plant and animal world (in other words the science of morphology), claims to be nothing more than a synthesis of the observed facts of its actual development, the science is co-ordinate and conterminous with living nature, and strives after a perfection which is that of nature itself.

Physiology is without this source of attractiveness. Its first lessons present difficulties to the beginner which, unless he is contented (as, indeed, ordinary students are) to accept as true what he does not understand, are, to say the least, discouraging; while to the more mature student, who has mastered more or less some part of the subject, it fails to present a system of knowledge of which all the parts are interdependent and can be referred to one fundamental principle, comparable to that of development or evolution.

It is easy to understand that this must be so if we consider the present position of the subject, and the nature of the work which the physiologist has to do. That work is of two kinds. He has first to determine what are the chemical and physical endowments of living matter in general, and of each of the varieties of living matter which constitute the animal and plant organism in particular. Then, these having been investigated, he has to determine how these processes are localized so as to constitute the special function of each structure, and the relation between structure and process in each case. The order I have indicated is the logical order, but in the actual progress of physiology this order has not been followed, *i.e.* there has not been a correlation of structure with previously investigated process, for in former days physiologists spoke of assimilation, secretion, contraction, and the like, as functions of muscles, glands, or other parts, without recognizing their ignorance of their real nature. But now, no one who is awake to the tendencies of thought and work in physiology, can fail to have observed that the best minds are directed with more concentration than ever before to those questions which relate to the elementary endowments of living matter, and that if they are still held in the background it is rather because of the extreme difficulty of approaching them than from any want of appreciation of their importance.

It is to some of these questions that I am anxious to draw the attention of the Section to-day. I feel that I have set myself a difficult task, but think that, even should I succeed very partially, the attempt may be a useful one. And I am encouraged by the consideration that the interest they possess is one which is common to plant and animal physiology, and that if we really understood them, they would furnish a key, not only to the phenomena of nutrition and growth, but even to those of reproduction and development, and by the belief that it is in the direction of elementary physiology, which means nothing more than the study of the endowments of living material, that the advance of the next twenty years will be made.

Nearly fifty years ago, J. R. Mayer's[1] treatise on the relation between organic motion and the exchange of material in living organisms was published in Germany. Although its value was more appreciated by physicists than by biologists, it was in its purpose, as well as in its subject-matter, physiological. In it Mayer showed for the first time that certain functions of the animal body, which up to that time had been considered most vital, are strictly within reach of measurement, *i.e.* referable to physical standards of quantity. He was even able to demonstrate that those quantitative relations between different kinds of energy which physicists were then only beginning to recognize, held good as regards the processes peculiar to the living organism.

Almost immediately after the appearance of this now celebrated work, a series of discoveries were made in physiology, which constituted the period we are now considering an epoch. Mayer himself had proved that muscles in doing work and producing heat do not do so at the expense of their own substance. But this fact could not be understood until Bernard showed that sugar is one of the most important constituents of the blood, and its storage and production a chief function of the liver. Helmholtz next succeeded in proving what Johannes Müller[2] had declared to be nearly impossible—namely, that the time occupied by the propagation of a motor impulse from the brain to a muscle could be measured, and showed it to be proportional to the distance traversed. Next, du Bois-Reymond investigated the electrical phenomena of living beings, and marshalled them under a physical theory which stood its ground against the severest criticism for more than a generation. And finally, the hydrodynamic principles relating to the circulation, set forth by Dr. Thomas Young in his Croonian Lecture forty

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[1] J. R. Mayer, "Die organische Bewegung in ihrem Zusammenhange mit dem Stoffwechsel" (Heilbronn, 1845).

[2] Müller's "Physiology," translation of second edition, p. 2[illegible]